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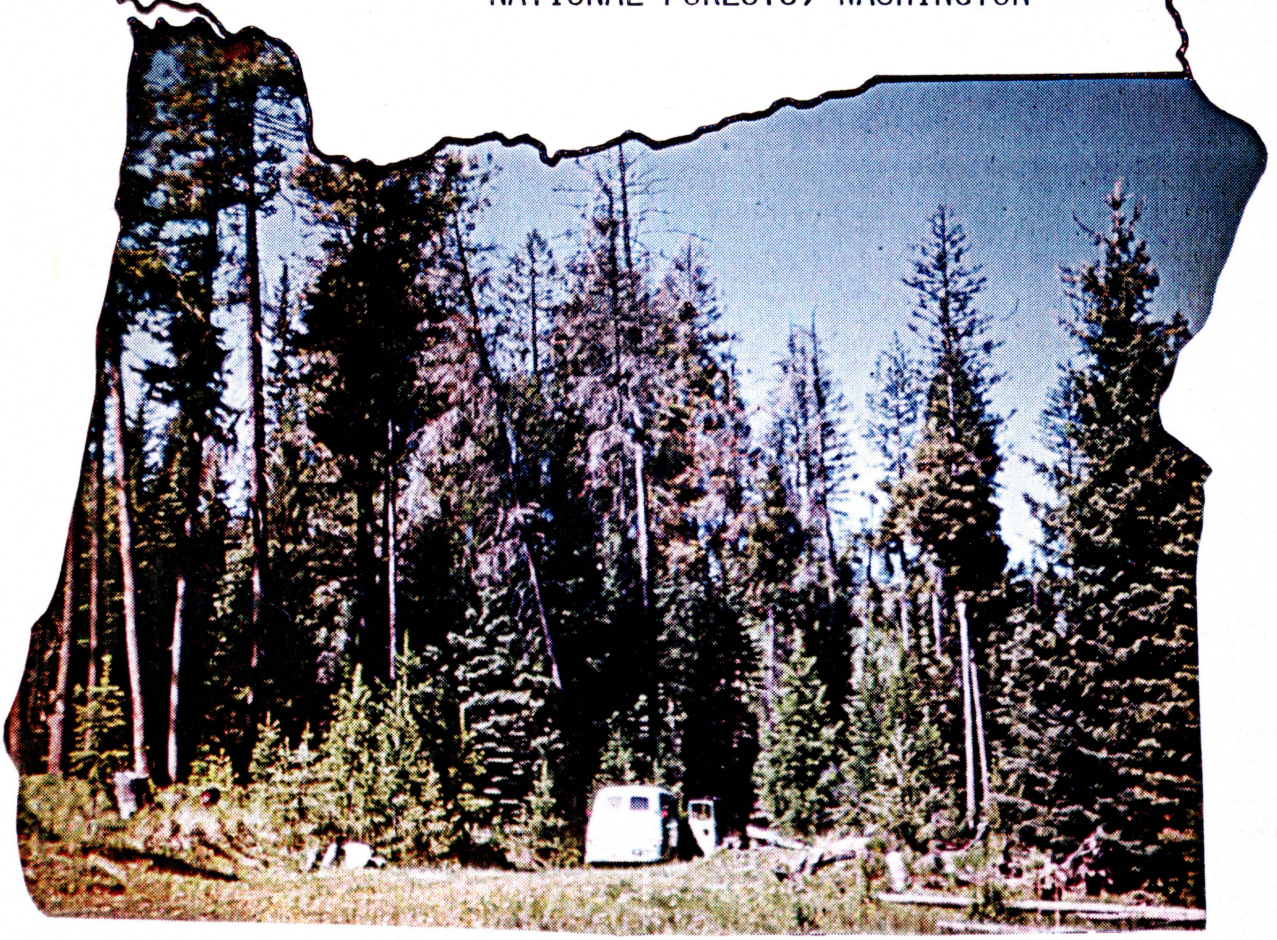

INCIDENCE OF DISEASES AND INSECT DAMAGE IN STANDS WITH MORTALITY AND PREVIOUS INFESTATION BY WESTERN SPRUCE BUDWORM ON THE WENATCHEE AND OKANOGAN NATIONAL FORESTS, WASHINGTON

by

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ABSTRACT

Of 102 stands sampled to measure damage caused by western spruce budworm, 7 stands with tree mortality, totaling 357 acres, were reexamined to determine causal agents. Much of the mortality was caused by root diseases, primarily *Phellinus weirii* and *Armillaria mellea*. Some mortality was associated with infections of dwarf mistletoes, chiefly *Arceuthobium douglasii* and *A. laricis*. Bark beetles, *Dendroctonus pseudotsugae, Scolytus ventralis*, and *Pseudohylesinus sericeus*, were associated with mortality, frequently in trees that also had root diseases or dwarf mistletoes. The cause of much of the mortality could not be identified, but western spruce budworm may have been involved. Pest management alternatives are discussed on a stand basis.

INTRODUCTION

Western spruce budworm, *Choristoneura occidentalis*, was reported to have caused extensive damage on 1.2 million acres of Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) on the Okanogan and Wenatchee National Forests in Washington (USDA Forest Service 1978). Damage ranged from defoliation to top-killing and tree mortality. Incidence of tree diseases in forests damaged by budworm has not been evaluated in the Pacific Northwest.

Dwarf mistletoes, *Arceuthobium* spp., are among the most destructive pathogens in Oregon and Washington forests, annually causing 72 million $ft.^3$ of mortality and 75 million $ft.^3$ of growth loss (Childs and Shea 1967). Losses are especially high east of the Cascade Range, including the Wenatchee and Okanogan National Forests (Bolsinger 1978). In south-central Oregon over a 10-year period, diameter increment of severely infected Douglas-fir was 57 percent less than uninfected trees (Shea 1963). In Montana, 10-year basal area growth of severely infected Douglas-firs was as much as 69 percent less than uninfected trees (Pierce 1960). There is no literature available on relationships between incidence of dwarf mistletoe and western spruce budworm.

Tree mortality caused by root diseases constitutes a major drain on forest productivity in the Pacific Northwest. Root rots account for mortality of 53 million $ft.^3$ and growth loss of 62 million $ft.^3$ annually (Childs and Shea 1967). East of the Cascade Range, loss is most serious in mixed fir and pine forests, a common association on the Okanogan and Wenatchee National Forests. Volume loss due to tree mortality caused by root diseases has been recorded at 35 ft^3/acre/year on two sites in south-central Washington (Shaw 1976, Filip 1981).

Incidence of damage caused by associations of root diseases and spruce budworm has not been studied well, especially in the West. In eastern Canada, Sterner (1970) found 38-92 percent of the balsam fir (*A. balsamea*) examined had butt rot after 0-7 years of suppression due to defoliation by spruce budworm (25 years since first attack). Although decay volumes were small, decay increased with "years of suppression." Whitney (1976) found that incidence of root rot increased with degree of damage by spruce budworm in balsam fir.

Others have studied the incidence of root diseases and occurrence of other insects. Hudak and Wells (1974) in eastern Canada found that incidence of root diseases increased with degree of damage by balsam woolly aphid (*Adelges piceae*) in balsam fir. Lane and Goheen (1979) in Oregon and Washington found that bark beetles appear to preferentially infest root-diseased true firs. No studies have been conducted in the West concerning relationships between incidence of root disease and damage caused by western spruce budworm.

An evaluation performed in 1980 quantified stand volume loss (growth loss, cull, and mortality) due to budworm infestation in 1970-1980 on the Okanogan and Wenatchee National Forests. Growth loss and cull due to diseases were evaluated simultaneously, and the results will appear in a later report.

OBJECTIVES

Objectives of this evaluation were to:

(1) select stands with mortality that was detected in plots established in the 102 stands evaluated during the 1980 loss assessment survey,

(2) determine incidence (trees and basal area per acre) of insect damage, diseases, and associated tree mortality in the selected stands, and

(3) use the survey data to develop pest management alternatives on a stand basis.

METHODS

Stand Selection

One hundred and two stands were selected from three budworm strata: (1) stands that did not have outbreak populations and, hence, were never treated with insecticides; (2) stands that experienced an outbreak and were treated with insecticides in 1975, 1976 and 1977, and (3) stands that experienced an outbreak but were never treated with insecticides. Treatments involved aerially applied fenitrothion in 1975, malathion in 1976, and Sevin-4-oil in 1977. From the 102 stands, we only examined stands with tree mortality detected on survey plots.

Plot Selection

Stands with mortality were sampled at a rate of 1 plot per 5 acres with a minimum of 10 and a maximum of 30 plots per stand. We used the same plots established during the larger loss assessment survey. Plots were located

systematically to cover the entire stand. At each plot center, trees greater than or equal to 5.0 inches DBH were tallied with a prism (20 BAF) and trees less than 5.0 in. DBH but greater than or equal to 1.0 in. DBH were tallied on fixed area (1/100 ac.) circular plots.

Data Collection

The following data were collected for each plot tree: (1) species, (2) DBH, (3) budworm-caused defoliation class, (4) dwarf mistletoe class, and (5) if dead, cause of mortality. Defoliation was recorded independently on current and older foliage of live trees on a scale of 0-4; zero being no defoliation and 4 being greater than 75% defoliation. Dwarf mistletoe was rated on live trees on a scale of 0-6; zero being no infection and 6 being heavy infection (Hawksworth 1977).

Cause of mortality was determined by examining trees for evidence of bark beetles, dwarf mistletoes, and root diseases. Bark beetles were detected by removing bark at DBH and examining for characteristic galleries. Dwarf mistletoes were detected by examining crowns for witches'-brooms and mistletoe plants. Root diseases were detected by chopping at the root collar and by limited excavation and dissection of roots near the root collar. Only dead or living symptomatic trees were examined for root diseases and bark beetles.

Laminated root rot caused by *Phellinus weirii* was detected by the presence of ectotrophic mycelium on the surface of exposed roots or by characteristic laminated decay with setal hyphae in old, dead material (Fig. 1). Armillaria root rot caused by *Armillaria mellea* was detected by the presence of mycelial fans beneath the bark (Fig. 2) or by yellow, stringy decay in old, dead material. Annosus root and butt rot caused by *Fomes annosus* was detected by the presence of white, stringy decay in old, dead material. No attempt was made to culture suspected pathogens.

RESULTS

Only 7 of 102 stands (4 from Stratum 2, 3 from Stratum 3) had any mortality recorded on plots, and all of these were revisited to determine causal agents. All but one stand (Goat Creek) occurred on the Wenatchee National Forest. Stands ranged in size from 19 to 123 acres and in elevation from 2,400-4,000 feet. All stands except Goat Creek had an understory of grand fir with an overstory of Douglas-fir, grand fir, or both. The stand at Goat Creek had a mixed understory of subalpine fir (*A. lasiocarpa*), ponderosa pine (*Pinus ponderosa*), and lodgepole pine (*P. contorta*) with an overstory of Douglas-fir and Engelmann spruce (*Picea engelmannii*).

GENERAL PEST CONDITION OF ALL STANDS

A total of 357 acres in 7 stands was surveyed with 88 plots (0.2 plots/acre). A mean of 42% of the total trees per acre (T/A) representing 23% of the total basal area per acre (BA/A) had either past or current defoliation caused by budworm (Table 1). Only trees with a defoliation class of 2 or greater in either current or past foliage were tabulated as damaged by budworm. Much of the defoliation occurred on saplings and small-diameter grand firs. No mortality directly attributable to budworm was observed.

Dwarf mistletoes on living trees were found in about 16% T/A representing 31% BA/A (Table 1). About 1% T/A representing about 2% BA/A were killed by dwarf mistletoes. A minor amount of dwarf mistletoe occurred with budworm, root diseases, or bark beetles on the same trees.

Root diseases, primarily caused by *A. mellea*, were found on about 5% T/A representing 6% BA/A, most of which had been killed. Some *P. weirii* and *F. annosus* were found. Root diseases occasionally were found on trees with dwarf mistletoe or bark beetles. No budworm-caused defoliation was detected in trees with root disease.

Bark beetles were found in about 1% T/A representing 2% BA/A, all of which were dead. Bark beetles occasionally were found on trees with dwarf mistletoe or root diseases.

About 4% T/A representing 4% BA/A were killed by undetermined causes. Many small trees may have died from excessive suppression, and the larger trees were often too deteriorated to determine cause of death. Some mortality may have resulted from excessive past defoliation by budworm.

In the 7 stands we examined, there appeared to be no correlation between budworm activity and incidence of particular diseases. Any associations appeared to be coincidental. Root diseases, particularly Armillaria root rot, and bark beetles may have affected trees weakened by budworm. Correlations, particularly between budworm, dwarf mistletoe, and damage will be examined and reported in the larger loss assessment evaluation.

Pest Management Alternatives

The following management alternatives describe the effects of various silvicultural treatments on incidence and damage caused by pests found in the seven examined stands. Specific alternatives accompanying descriptions of each stand appear later in this report.

(1) No treatment. Dwarf mistletoes will cause the most damage both as tree mortality and growth loss, especially in Douglas-fir and western larch (*Larix occidentalis*). Root diseases and bark beetles will continue to affect trees weakened by other causes. In some stands, laminated root rot will continue to reduce productivity, infecting and killing even vigorous trees. Budworm will continue to sporadically defoliate grand fir, Douglas-fir, subalpine fir, and Engelmann spruce where they occur, primarily causing growth loss in most stands. Some tree mortality and top-kill may occur in stands defoliated over several successive years.

(2) Sanitation-salvage. Most of the dead trees will be utilized before they deteriorate. Dwarf mistletoes will continue to infect susceptible understories unless all infected overstory trees are removed. Larch dwarf mistletoe will not infect Douglas-fir and Douglas-fir dwarf mistletoe will not infect larch. True fir, Engelmann spruce, white pine (*P. monticola*), and cedar (*Thuja plicata*) rarely are infected by dwarf mistletoes. Unless Douglas-fir, larch, or the true firs are discriminated against in areas with laminated root rot, infection and mortality will increase. Budworm also will continue to cause damage if Douglas-fir, larch, or true fir are not removed.

(3) Commercial thinning, shelterwood, or seed tree systems. Favoring true firs, white pine (rust free), cedar, or spruce will reduce the dwarf mistletoe problem, but the true firs will be prone especially to budworm damage and other diseases such as root rots and heartrots. Ponderosa pine and lodgepole pine may be favored if mistletoe-free.

(4) Clearcutting and replanting. All of the merchantable timber will be harvested in one operation, thus eliminating damage to regeneration during entries. Dwarf mistletoe will be eliminated from the site if all infected unmerchantable trees are destroyed during logging. Plant with Douglas-fir, larch, or pines at least 100 feet from mistletoe-infested unit margins. In areas with laminated root rot, planting or favoring natural regeneration of pine, spruce, or cedar, where adapted, will reduce future damage caused by laminated root rot and budworm as well.

Stand-by-Stand Analysis

1. Swauk Pass, Ellensburg Ranger District

The stand at Swauk Pass (T. 21 N., R. 18 E., Sec. 9) is 64 acres in size, at elevation 4,000 feet, and contains primarily grand fir both in the overstory and understory. Some Engelmann spruce, Douglas-fir, and western larch also occur.

All 12 plots had evidence of budworm damage and all but 1 had dwarf mistletoe. Root diseases and bark beetles were found in 3 and 2 plots, respectively. Seven of 12 plots had mortality, most (84%) of which was caused by dwarf mistletoes.

About half of the T/A representing 30% BA/A was damaged by budworm (Table 2). No defoliation was detected in western larch. None of the mortality could be attributed directly to budworm.

About 11% T/A representing 27% BA/A were infected with dwarf mistletoes (*A. laricis* and *A. douglasii*) primarily in western larch and Douglas-fir, respectively, but some in small lodgepole pine by *A. americanum* or possibly *A. laricis*. No dwarf mistletoe was found in grand fir or spruce. About half of the infected trees were dead, probably killed by dwarf mistletoe. Some of the dead trees with dwarf mistletoe also had bark beetles, most probably *D. pseudotsugae*. Dwarf mistletoe infection levels in individual trees were moderate to heavy.

Root diseases were found in only 1% T/A representing 1% BA/A, and all trees were dead. Most of the mortality was associated with *F. annosus* in large Douglas-firs and small lodgepole pines. Some Armillaria root rot was found in large, grand fir.

Suggested Pest Management Alternatives - Swauk Pass

Because of the serious growth loss and mortality due to dwarf mistletoes, one of the following alternatives should be initiated as soon as possible:

(1) partial cut favoring spruce and mistletoe-free Douglas-fir and larch. Retain unwounded grand fir if stocking with the above species is inadequate. Thin the understory leaving only mistletoe-free, unwounded, vigorous residuals,

or

(2) clearcut and plant Douglas-fir or larch at least 100 feet from mistletoe-infested unit margins.

2. Victoria Creek #1, Leavenworth Ranger District

Stand #1 at Victoria Creek (T. 24 N., R. 16 E., Sec. 10) is 40 acres in size, at elevation 3,800 feet, and contains primarily Douglas-fir in the overstory and grand fir in the understory. Other species occur in minor amounts.

All 10 plots had dwarf mistletoe and all but 1 had budworm damage. Root diseases and bark beetles were found on only 1 plot each (different plots). Only 2 plots had mortality caused by either root diseases or bark beetles.

About 77% T/A representing 42% BA/A were damaged by budworm (Table 3). Much of the damage occurred in small diameter grand and Douglas-fir. None of the mortality could be attributed directly to budworm. Many of the trees with budworm damage also had dwarf mistletoes, especially the larger trees.

About 11% T/A representing 17% BA/A were infested with dwarf mistletoes, primarily in Douglas-fir. None of the infected trees were dead. Infection levels ranged from light to heavy in individual trees.

Root diseases were found in only 1% T/A representing 5% BA/A. All trees were dead and infected by *A. mellea*. Root disease in this case was probably secondary to some other weakening agent, possibly budworm. Bark beetles (*D. pseudotsuga*) were found on one Douglas-fir possibly weakened by other factors.

About 2% T/A representing 9% BA/A were killed from unidentified causes. Many of these were too deteriorated to identify causes, but some mortality may have been due to past budworm defoliation.

Suggested Pest Management Alternatives - Victoria Creek #1

Although no mortality could be attributed to dwarf mistletoes, almost a third of the Douglas-fir basal area is infected. One of the following alternatives should be initiated eventually:

(1) partial cut favoring mistletoe-free Douglas-fir, vigorous, unwounded grand fir, or any other disease-free species on the site; thin the understory, leaving only vigorous, unwounded, mistletoe-free trees,

or

(2) clearcut and plant Douglas-fir at least 100 feet from mistletoe-infested unit margins.

3. Victoria Creek #2, Leavenworth Ranger District

Stand #2 at Victoria Creek (T. 24 N., R. 16 E., Sec. 10) is 19 acres in size, at elevation 2,800 feet, and composed primarily of grand fir in both the overstory and understory. Some Douglas-fir, western redcedar, and lodgepole pine also occur.

Of 10 plots, all but 1 had budworm damage and 8 had dwarf mistletoe. Root diseases were found on 3 plots and bark beetles on 1. Six of 10 plots had mortality caused primarily by root diseases.

About 55% T/A, representing 41% BA/A, were damaged by budworm (Table 4). Most of the damage occurred in small diameter grand firs, and some had dead tops. Although none of the mortality could be attributed directly to budworm, the cause of death of several small grand firs could not be determined, and mortality may have been caused by past budworm defoliation. Some of the larger Douglas-firs with budworm damage also had dwarf mistletoes.

About 9% T/A representing 29% BA/A were infected with dwarf mistletoes. None of the infected trees were dead. Infection levels ranged from light to heavy. All of the dwarf mistletoe was in lodgepole pine and Douglas-fir.

Root diseases were found in 9% T/A representing 6% BA/A, and most of the trees were suppressed grand fir killed by *A. mellea*. *Phellinus weirii* was found in one living Douglas-fir and one dead grand fir with *A. mellea* also.

About 11% T/A representing 8% BA/A were killed by unidentified causes. As previously mentioned, much of the mortality may have been caused by budworm in the grand fir regeneration.

Suggested Pest Management Alternatives - Victoria Creek #2

Although no mortality could be attributed to dwarf mistletoes, most of the Douglas-fir and lodgepole were infected. One of the following alternatives should be initiated:

(1) partial cut, favoring mistletoe-free Douglas-fir, vigorous, unwounded grand fir, or any other disease-free species on the site; thin the understory, leaving only vigorous, unwounded, mistletoe-free trees,

or

(2) clearcut and plant Douglas-fir at least 100 feet from mistletoe-infested unit margins.

4. Little Creek #1, Cle Elum Ranger District

Stand #1 at Little Creek (T. 19 N., R. 14 E., Sec. 4) is 63 acres in size, at elevation 2,800 feet, and composed primarily of grand fir in the overstory with a grand fir-Douglas-fir understory. Some ponderosa pine, lodgepole pine, western larch, cedar, and subalpine fir also occur.

All 12 plots had budworm damage and 9 had dwarf mistletoes. Root diseases and bark beetles were found on 8 and 3 plots, respectively. Eight plots had some mortality, mostly caused by root diseases.

About 52% T/A, representing 31% BA/A, were damaged by budworm (Table 5). No top-kill or mortality could be attributed directly to budworm. Some of the Douglas-fir with budworm damage also had dwarf mistletoes.

About 5% T/A, representing 19% BA/A, were infected with dwarf mistletoes. About a third of the infected trees were dead. Infection levels were light to moderate in individual trees. Dwarf mistletoe was found in some larch with *P. weirii* also. Most of the dwarf mistletoe was in larch, but some was found in Douglas-fir.

Root diseases were found in 14% T/A, representing 23% BA/A. Most of the infected trees were dead. *Phellinus weirii* was found mainly in the larger trees and *A. mellea* chiefly in the smaller trees. Some *P. weirii* was found in living, infected trees. Douglas-fir, grand fir, larch, and subalpine fir were all heavily infected with *P. weirii*. *Armillaria mellea* appeared to be associated with trees weakened by other factors, possibly budworm. Laminated root rot constitutes a serious obstacle to full productivity of this stand.

Bark beetles, primarily fir engravers (*Scolytus ventralis*) on grand fir and possibly *Pseudohylesinus sericeus* on subalpine fir, were found in 6% T/A representing 8% BA/A. Almost half of the infestations were in trees infected by root diseases.

About 1% T/A, representing 1% BA/A, were killed by unidentified causes and occurred in suppressed grand fir.

Suggested Pest Management Alternatives - Little Creek #1

Because of the heavy losses due to laminated root rot, one of the following alternatives should be initiated as soon as possible:

(1) partial cut, favoring ponderosa pine, lodgepole pine, or cedar; remove all Douglas-fir, larch, grand fir, and subalpine fir to capture potential losses and prevent their regeneration since these species are damaged heavily by laminated root rot; thin the understory, leaving only vigorous ponderosa pine, lodgepole pine, or cedar; dwarf mistletoe and budworm-caused damage also will be reduced by this alternative,

or

(2) clearcut, destroy all advanced regeneration, and plant ponderosa pine, lodgepole pine, or cedar depending on site; prevent regeneration of fir and larch by cutting as large a unit as possible; this stand may be a good candidate for stump removal to prevent root disease in the next rotation; following stump removal, Douglas-fir and larch could be planted safely.

5. Little Creek #2, Cle Elum Ranger District

Stand #2 at Little Creek (T. 20 N., R. 14 E., Sec. 32) is 123 acres in size, at elevation 2,800 feet, and composed primarily of Douglas-fir in the overstory and a Douglas-fir/grand fir mix in the understory. Some western larch, white pine, lodgepole pine, and cedar also are present.

All 24 plots had dwarf mistletoe and none had detectable budworm damage. Root diseases were found in 21% of the plots. Twenty-nine percent of the plots had mortality, mostly caused by root diseases.

Dwarf mistletoes were found in 67% T/A, representing 80% BA/A, primarily in Douglas-fir and larch (Table 6). Very few of the mistletoe-infected trees were dead. Infection levels were moderate to heavy in individual trees. Dwarf mistletoes were found occasionally in trees with root disease also.

Root diseases were found in 5% T/A, representing 7% BA/A, and more than half of the trees were dead. Most of the infection was caused by *P. weirii* in Douglas-fir and larch. Some *Fomes annosus* was found in Douglas-fir and larch with dwarf mistletoes also. Although present in this stand, laminated root rot has not caused the level of damage that it has in Little Creek Stand #1.

About 3% T/A, representing 1% BA/A, were killed by unidentified causes primarily in suppressed Douglas-fir.

Suggested Pest Management Alternatives - Little Creek #2

Because of the high incidence of dwarf mistletoe and scattered occurrence of laminated root rot, one or both of the following alternatives should be initiated as soon as possible:

(1) partial cut favoring white pine (rust free), lodgepole pine, and cedar; in areas devoid of these species and root disease, mistletoe-free Douglas-fir or larch may be retained; as a last resort, retain grand fir; thin the understory and favor species as above,

or

(2) clearcut, destroy all advanced regeneration, and plant white pine (rust resistant), lodgepole pine, or cedar in areas with root disease; plant Douglas-fir or larch if root disease-free areas can be identified; the topography is too steep to consider stump removal in this stand.

6. Wenatchee River, Lake Wenatchee Ranger District

The Wenatchee River stand (T. 27 N., R. 15 E., Sec. 10, 11) is 24 acres in size, at elevation 2,400 feet, and composed primarily of Douglas-fir in the overstory and grand fir and cedar in the understory. Some ponderosa and lodgepole pine occur.

Of 10 plots, 2 had budworm damage, 4 had dwarf mistletoe, and 3 had root disease. Only 3 of 10 plots had tree mortality, mostly caused by root disease.

About 3% T/A, representing 2% BA/A, were damaged by budworm (Table 7). No mortality could be attributed directly to budworm. All of the damage was in Douglas-fir regeneration or mid-diameter (15-19 in. DBH) grand fir.

Dwarf mistletoes were found in 4% T/A, representing 22% BA/A, and all but a small amount occurring in Douglas-fir. All mistletoe-infected trees were living. Infection levels were high in individual trees.

Root disease was found in 4% T/A representing 1% BA/A. Infection was exclusively by *A. mellea* in Douglas-fir suppressed regeneration or small-diameter grand fir. All infected trees were dead.

Only 1% T/A, representing 5% BA/A, were killed by unidentified causes. All of the unidentified mortality occurred in old-growth cedar.

Suggested Management Alternatives - Wenatchee River

No immediate treatment is necessary in this stand. At harvest, one of the following alternatives should be initiated:

(1) partial cut favoring pine, cedar, dwarf mistletoe-free Douglas-fir, and thrifty, unwounded grand fir; thin the understory, leaving only vigorous, unwounded, mistletoe-free trees,

or

(2) clear cut and plant Douglas-fir at least 100 feet from mistletoe-infested unit margins.

7. Goat Creek, Winthrop RD

The stand at Goat Creek (T. 36 N., R. 20 E., Sec. 9) is 24 acres in size, at elevation 4,000 feet, and composed primarily of Douglas-fir and spruce in the overstory and subalpine fir, ponderosa pine, and lodgepole pine in the understory.

All 10 plots had evidence of budworm damage, 4 had dwarf mistletoe, and 3 had bark beetles. No plots had detectable root disease. Four of 10 plots had mortality caused primarily by bark beetles.

Budworm damage was evident in 66% T/A, representing 66% BA/A, and was heavy in Douglas-fir, spruce, and subalpine fir (Table 8). At least half of the trees had dead tops. Most of the mortality (7% T/A, 4% BA/A) was probably caused by budworm.

Dwarf mistletoes were found in 15% T/A, representing 9% BA/A, and all trees were still alive. Only lodgepole pine and Douglas-fir were infected and at moderate levels in individual trees.

Suggested Pest Management Alternatives - Goat Creek

This stand probably should be regenerated as soon as possible because of the heavy damage caused by budworm. The following alternatives are suggested:

(1) remove unthrifty, top-killed, and mistletoe-infected trees during a seed tree or shelterwood cut; thin the understory and retain only vigorous, mistletoe-free crop trees with good crowns,

or

(2) clearcut and plant with any species adapted to the site; if Douglas-fir or lodgepole is regenerated, leave a 100-foot buffer between mistletoe-infested unit margins and regeneration.

CONCLUSIONS

Most of the tree mortality that could be identified as to cause was due to root diseases. However, most of the root disease was caused by *A. mellea* which has a history of killing trees weakened by other agents or appearing in trees killed by other causes, possibly severe and repeated defoliation by budworm in both cases. Also, much of the mortality that could not be identified as to causal agent was either in trees too deteriorated to determine cause or in small suppressed trees. Many of these trees, especially in the latter case, may have been killed during the budworm infestations of 1970-1980. Evidence of prior budworm defoliation was not detected unless defoliation occurred 1 or 2 years prior to our survey. Therefore, trees defoliated and killed during 1970-1980 were recorded as "dead-unknown" if other agents were not detected. On the Okanogan and Wenatchee National Forests, mortality associated with budworm was infrequent, since only 7 out of 120 stands examined had detectable tree mortality on survey plots.

All but 2 stands, Little Creek #2 and Wenatchee River, have detectable damage caused by budworm. Defoliation in most stands was in overstocked regeneration of grand fir or Douglas-fir. In only one stand, Goat Creek, does budworm appear to be causing substantial top-kill in the overstory. Dwarf mistletoe, primarily in Douglas-fir and larch, is prevalent in nearly all stands and is especially heavy in Little Creek #2. In one stand, Victoria Creek #1, budworm damage and dwarf mistletoe occur together on the same tree.

Root diseases were found associated with mortality in all but 1 stand, Goat Creek. Much of the infection was caused by *A. mellea* in trees weakened by other factors, quite possibly budworm. In two stands, Little Creek #1 and #2, substantial infection and mortality was caused by *P. weirii*. Bark beetles were found occasionally in trees infected by *P. weirii*.

It is not known if the budworm problem, chronic to the areas surveyed, can be reduced through silvicultural means short of favoring non-hosts such as pines or cedars during harvesting and planting operations. Such an alternative will reduce damage caused by laminated root rot, since these species are resistant to *P. weirii* infection and mortality (Hadfield and Johnson 1977). Maintenance of vigorous stands, however, may offset growth loss due to repeated years of budworm attack.

Pest management should be directed toward reducing losses caused by dwarf mistletoes in most stands. Good silviculture should accomplish this. Stands where laminated root rot is present will require special treatment such as harvesting and planting to favor *P. weirii*-resistant trees.

The information and recommendations presented in this report have been specifically formulated for the areas we surveyed. Although some of this information may be applied to other areas in Oregon and Washington experiencing similar pest problems, these areas may be sufficiently different from the areas we surveyed to warrant a separate biological evaluation to formulate management alternatives specific to that area. FPM staff encourage and are available to perform such evaluations at the request of land managers.

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TABLE 1--Incidence of Disease and Insect Damage in Seven Stands Previously Infested by Western Spruce Budworm on the Wenatachee and Okanogan National Forests

WSBW Stratum	Stand Location		Total	Healthy	BW Live	DM-BW Live	DM-PW Live	DM Live	PW Live	DM Dead	PW Dead	AM Dead	FA Dead	DM-PW Dead	DM-FA Dead	PW-AM Dead	BB Dead	DM-BB Dead	BB-PW Dead	BB-AM Dead	Unk. Dead
2	Swauk Pass	T/A	560.2	204.9	285.7	1.5	0	30.8	0	28.6	0	0.6	5.4	0	0	0	0	2.7	0	0	0
		BA/A	135.8	53.7	40.1	3.4	0	20.0	0	6.7	0	1.7	3.4	0	0	0	0	6.8	0	0	0
2	Victoria Creek #1	T/A	364.6	56.0	256.4	23.1	0	15.8	0	0	0	4.2	0	0	0	0	1.9	0	0	0	7.2
		BA/A	128.0	26.0	24.0	30.0	0	28.0	0	0	0	6.0	0	0	0	0	2.0	0	0	0	12.0
2	Victoria Creek #2	T/A	633.5	103.0	346.0	6.0	0	53.6	1.1	0	0	54.7	0	0	0	0.6	0	0	0	0	68.5
		BA/A	172.0	40.0	58.0	12.0	0	38.0	2.0	0	0	6.0	0	0	0	2.0	0	0	0	0	14.0
3	Little Creek #1	T/A	333.3	86.7	167.8	4.3	2.8	5.7	6.2	5.1	17.5	11.6	0	0	0	0	13.2	0	3.7	3.9	4.8
		BA/A	147.8	45.0	36.8	8.4	3.4	8.4	10.2	8.5	10.1	3.4	0	0	0	0	5.1	0	3.4	3.4	1.7
3	Little Creek #2	T/A	433.3	116.5	0	0	8.5	275.4	0	7.2	10.1	0	0	1.1	3.7	0	0	0	0	0	10.9
		BA/A	150.8	26.5	0	0	5.7	108.9	0	2.5	2.4	0	0	0.8	2.4	0	0	0	0	0	1.6
3	Wenatchee River	T/A	390.4	345.9	12.5	0	0	15.9	0	0	0	13.7	0	0	0	0	0	0	0	0	2.4
		BA/A	170.0	118.0	4.0	0	0	38.0	0	0	0	2.0	0	0	0	0	0	0	0	0	9.0
2	Goat Creek	T/A	303.3	24.4	199.8	0	0	46.6	0	0	0	0	0	0	0	0	0.3	0	0	0	32.2
		BA/A	106.0	20.0	70.0	0	0	10.0	0	0	0	0	0	0	0	0	2.0	0	0	0	4.0
	Average	T/A	431.2	133.9	181.2	5.0	1.6	63.4	1.0	5.8	3.9	12.1	0.8	0.2	0.5	0.1	2.2	0.4	0.5	0.6	18.0
		BA/A	144.3	47.0	33.3	7.7	1.3	35.9	1.7	2.5	1.8	2.7	0.5	0.1	0.3	0.3	1.3	1.0	0.5	0.5	5.9
	Percent	T/A		31.1	42.0	1.2	0.4	14.7	0.2	1.3	0.9	2.8	0.2	<0.1	0.1	<0.1	0.5	<0.1	0.1	0.1	4.1
		BA/A		32.6	23.1	5.3	0.9	24.9	1.2	1.7	1.2	1.9	0.3	<0.1	0.2	0.2	0.9	0.7	0.3	0.3	4.1

ABBREVIATIONS FOR ALL TABLES:

T/A - trees per acre
BA/A - basal area per acre
BW - budworm
DM - dwarf mistletoe
PW - Phellinus weirii
AM - Armillaria mellea
FA - Fomes annosus
BB - bark beetle
Unk. - unknown

TABLE 2--Incidence of Diseases and Insect Damage in the Swauk Pass Stand, Ellensburg RD by tree species and DBH class.

		DOUGLAS-FIR					GRAND FIR			WESTERN LARCH			LODGEPOLE PINE		ENGELMANN SPRUCE	
DBH Class		Healthy	BW Live	DM+BW Live	DM+BB Dead	FA Dead	Healthy	BW Live	AM Dead	DM Live	DM Dead	DM&BB Dead	DM Live	FA Dead	Healthy	BW Live
1.0-4.9	T/A	0	16.7	0	0	0	108.3	141.7	0	0	0	0	16.7	0	0	50.0
5.0-6.9	T/A	8.5	0	0	0	0	8.5	42.9	0	0	25.5	0	0	0	17.0	0
	BA/A	1.7	0	0	0	0	1.7	8.3	0	0	5.0	0	0	0	3.3	0
7.0-8.9	T/A	0	0	0	0	0	19.1	4.8	0	0	0	0	0	4.8	0	0
	BA/A	0	0	0	0	0	6.7	1.7	0	0	0	0	0	1.7	0	0
9.0-10.9	T/A	0	3.1	0	0	0	21.4	9.2	0	0	3.1	0	3.1	0	0	0
	BA/A	0	1.7	0	0	0	11.7	5.0	0	0	1.7	0	1.7	0	0	0
11.0-12.9	T/A	0	0	0	0	0	6.6	4.2	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	0	5.0	3.3	0	0	0	0	0	0	0	0
13.0-14.9	T/A	1.6	1.6	0	0	0	1.6	4.7	0	3.1	0	0	0	0	1.6	0
	BA/A	1.7	1.7	0	0	0	1.7	5.0	0	3.3	0	0	0	0	1.7	0
15.0-16.9	T/A	1.2	0	0	0	0	1.2	1.2	0	2.4	0	0	0	0	1.2	0
	BA/A	1.7	0	0	0	0	1.7	1.7	0	3.3	0	0	0	0	1.7	0
17.0-18.9	T/A	0	0	0.9	0	0	0.9	1.9	0	3.8	0	0.9	0	0	0	0.9
	BA/A	0	0	1.7	0	0	1.7	3.3	0	6.7	0	1.7	0	0	0	1.7
19.0-20.9	T/A	0	0.8	0	0	0	0	0	0	0	0	0.8	0	0	3.8	1.5
	BA/A	0	1.7	0	0	0	0	0	0	0	0	1.7	0	0	5.0	3.3
21.0-22.9	T/A	0	0	0.6	0	0.6	0	0	0.6	1.3	0	0	0	0	1.9	0
	BA/A	0	0	1.7	0	1.7	0	0	1.7	3.3	0	0	0	0	5.0	0
23.0-24.9	T/A	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0.5	0
	BA/A	0	0	0	1.7	0	0	0	0	0	0	0	0	0	1.7	0
25.0-26.9	T/A	0	0	0	0	0	0	0.5	0	0	0	0.5	0	0	0	0
	BA/A	0	0	0	0	0	0	1.7	0	0	0	1.7	0	0	0	0
27.0-28.9	T/A	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0
	BA/A	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0
Total	T/A	11.3	22.2	1.5	0.5	0.6	167.6	211.1	0.6	11.0	28.6	2.2	19.8	4.8	26.0	52.4
	BA/A	5.1	5.1	3.4	1.7	1.7	30.2	30.0	1.7	18.3	6.7	5.1	1.7	1.7	18.4	5.0
Percent (within species)	T/A	31.3	61.5	4.2	1.4	1.7	44.2	55.6	0.2	26.3	68.4	5.3	80.5	19.5	33.2	66.8
	BA/A	30.0	30.0	20.0	10.0	10.0	48.8	48.5	2.7	60.8	22.3	16.9	50.0	50.0	78.6	21.4

TABLE 3--Incidence of Diseases and Insect Damage in the Victoria Creek Stand #1, Leavenworth RD by Tree Species and DBH Class

DBH CLASS		DOUGLAS-FIR							GRAND FIR			SUBALPINE FIR ENGELMANN SPRUCE WHITE PINE LODGEPOLE PINE		
		Healthy	BW Live	DM-BW Live	DM Live	BB Dead	AM Dead	Unk. Dead	Healthy	BW Live	Unk. Dead	Healthy	DM Live	BW Live
1.0-4.9	T/A	0	10.0	0	0	0	0	0	20.0	180.0	0	0	0	10.0
5.0-6.9	T/A	20.4	10.2	0	0	0	0	0	0	20.4	0	0	0	0
	BA/A	4.0	2.0	0	0	0	0	0	0	4.0	0	0	0	0
7.0-8.9	T/A	0	11.5	5.7	0	0	0	0	0	5.7	0	0	0	0
	BA/A	0	4.0	2.0	0	0	0	0	0	2.0	0	0	0	0
9.0-10.9	T/A	0	0	0	0	0	0	0	0	3.7	0	0	0	0
	BA/A	0	0	0	0	0	0	0	0	2.0	0	0	0	0
11.0-12.9	T/A	0	0	0	0	0	0	0	0	0	0	2.5	0	0
	BA/A	0	0	0	0	0	0	0	0	0	0	2.0	0	0
13.0-14.9	T/A	0	0	5.6	3.7	1.9	1.9	1.9	5.6	0	1.9	1.9	0	0
	BA/A	0	0	6.0	4.0	2.0	2.0	2.0	6.0	0	2.0	2.0	0	0
15.0-16.9	T/A	0	2.9	7.2	4.3	0	0	0	0	0	0	1.4	1.4	0
	BA/A	0	4.0	10.0	6.0	0	0	0	0	0	0	2.0	2.0	0
17.0-18.9	T/A	1.1	0	1.1	2.3	0	2.3	2.3	1.1	0	0	0	0	0
	BA/A	2.0	0	2.0	4.0	0	4.0	4.0	2.0	0	0	0	0	0
19.0-20.9	T/A	0	0	1.8	0.9	0	0	0	0	0	0	0	0	0
	BA/A	0	0	4.0	2.0	0	0	0	0	0	0	0	0	0
21.0-22.9	T/A	0	0.8	0	0.8	0	0	0	1.5	0.8	0	0	0	0
	BA/A	0	2.0	0	2.0	0	0	0	4.0	2.0	0	0	0	0
23.0-24.9	T/A	0	0	0.6	1.9	0	0	0.6	0	0	0	0	0	0
	BA/A	0	0	2.0	6.0	0	0	2.0	0	0	0	0	0	0
25.0-26.9	T/A	0	0	1.1	0.5	0	0	0	0.5	0	0	0	0	0
	BA/A	0	0	4.0	2.0	0	0	0	2.0	0	0	0	0	0
27.0-28.9	T/A	0	0	0	0	0	0	0.5	0	0	0	0	0	0
	BA/A	0	0	0	0	0	0	2.0	0	0	0	0	0	0
29.0-30.9	T/A	0	0	0	0	0	0	0	0	0.4	0	0	0	0
	BA/A	0	0	0	0	0	0	0	0	2.0	0	0	0	0
Total	T/A	21.5	35.4	23.1	14.4	1.9	4.2	5.3	28.7	211.0	1.9	5.8	1.4	10.0
	BA/A	6.0	12.0	30.0	26.0	2.0	6.0	10.0	14.0	12.0	2.0	6.0	2.0	<0.1
Percent (within species)	T/A	20.3	33.5	21.8	13.6	1.8	4.0	5.0	11.9	87.3	0.8	33.8	8.1	58.1
	BA/A	6.5	13.0	32.6	28.3	2.2	6.5	10.9	50.0	42.9	7.1	75.0	25.0	<0.1

Table 4 - Incidence of diseases and insect damage in the Vi Creek Stand #2, Leavenworth RD by tree species and DBH class

DBH CLASS		DOUGLAS-FIR					GRAND FIR					RED CEDAR	LODGEPOLE PINE		PONDEROSA PINE WESTERN LARCH ENGELMANN SPRUCE	
		BW Live	DM-BW Live	DM Live	PW Live	UNK Dead	Healthy	BW Live	AM Dead	AM-PW Dead	UNK Dead	Healthy	DM Live	UNK Dead	Healthy	BW Live
1.0- 4.9	T/A	0	0	0	0	0	30.0	180.0	40.0	0	20.0	30.0	0	10.0	20.0	20.0
5.0- 6.9	T/A	10.2	0	0	0	0	0	61.2	10.2	0	20.4	0	10.2	0	10.2	0
	BA/A	2.0	0	0	0	0	0	12.0	2.0	0	4.0	0	2.0	0	2.0	0
7.0- 8.9	T/A	0	0	0	0	5.7	17.2	28.7	0	0	0	0	5.7	5.7	0	0
	BA/A	0	0	0	0	2.0	6.0	10.0	0	0	0	0	2.0	2.0	0	0
9.0-10.9	T/A	7.3	0	0	0	0	0	14.7	3.7	0	3.7	0	18.3	0	0	7.3
	BA/A	4.0	0	0	0	0	0	8.0	2.0	0	2.0	0	10.0	0	0	4.0
11.0-12.9	T/A	0	0	2.5	0	0	0	5.1	0	0	0	5.1	5.1	2.5	0	0
	BA/A	0	0	2.0	0	0	0	4.0	0	0	0	4.0	4.0	2.0	0	0
13.0-14.9	T/A	3.7	0	1.9	0	0	1.9	5.6	0	0	0	1.9	5.6	0	0	0
	BA/A	4.0	0	2.0	0	0	2.0	6.0	0	0	0	2.0	6.0	0	0	0
15.0-16.9	T/A	1.4	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	2.0	2.0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0-18.9	T/A	0	3.4	1.1	1.1	0	1.1	1.1	0	0	0	0	1.1	0	0	0
	BA/A	0	6.0	2.0	2.0	0	2.0	2.0	0	0	0	0	2.0	0	0	0
19.0-20.9	T/A	0	0	0.9	0	0	1.8	0	0	0	0	0	0	0	0	0
	BA/A	0	0	2.0	0	0	4.0	0	0	0	0	0	0	0	0	0
21.0-22.9	T/A	0	0	0	0	0	0.8	0	0.8	0	0	1.5	0	0	0.8	0
	BA/A	0	0	0	0	0	2.0	0	2.0	0	0	4.0	0	0	2.0	0
23.0-24.9	T/A	0	0	0	0	0	0	0	0	0.6	0	0.6	0	0	0	0
	BA/A	0	0	0	0	0	0	0	0	2.0	0	2.0	0	0	0	0
25.0-26.9	T/A	0	1.2	1.2	0	0.5	0	0	0	0	0	0	0	0	0	0
	BA/A	0	4.0	4.0	0	2.0	0	0	0	0	0	0	0	0	0	0
29.0-30.9	T/A	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	0	2.0	0	0	0	0	0	0	0	0	0
37.0-38.9	T/A	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	0	4.0	0	0	0	0	0	0	0	0	0
43.0-44.9	T/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
	BA/A	0	0	0	0	0	0	0	0	0	0	0	0	0	2.0	0
Total	T/A	22.3	6.0	7.6	1.1	6.2	53.7	296.4	54.7	0.6	44.1	9.1	46.6	18.2	40.2	27.3
	BA/A	12.0	12.0	12.0	2.0	4.0	22.0	42.0	6.0	2.0	6.0	12.0	26.0	4.0	6.0	4.0
Percent (within species)	T/A	51.6	13.9	17.6	2.5	14.4	11.9	66.0	12.2	0.1	9.8	100.0	71.7	28.3	59.6	40.4
	BA/A	28.6	28.6	28.6	6.0	9.5	28.2	53.8	7.7	2.6	7.7	100.0	86.7	33.3	60.0	40.0

Table 5 — Incidence of disease and insect activity in the **Little Creek Stand #1,** Cle Elum RD by tree species and DBH class.

		DOUGLAS-FIR							GRAND FIR								Lodgepole Pine Ponderosa Pine Red Cedar	LARCH					SUBALPINE FIR		
			BW	DM-BW	DM	PW	PW	DM	BW	PW	PW	BB-PW	AM	BB-AM	UNK				DM-BW	DM-PW	DM	PW	AM	BB-PW	BB
DBH CLASS		Healthy	Live	Live	Live	Live	Dead	Dead	Live	Live	Dead	Dead	Dead	Dead	Dead	Dead	Healthy	Healthy	Live	Live	Dead	Dead	Dead	Dead	Dead
1.0-4.9	T/A	0	0	0	0	0	0	0	133.0	0	8.3	0	8.3	8.3	0	0	50.0	0	0	0	0	0	0	0	0
5.0-6.9	T/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.5	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0
7.0-8.0	T/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.8	4.8	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	1.7	0	0	0	0	0	0	0	0
9.0-10.9	T/A	0	0	0	0	3.1	0	0	15.3	0	0	0	0	0	3.1	0	12.2	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	1.7	0	0	8.3	0	0	0	0	0	1.7	0	6.6	0	0	0	0	0	0	0	0
11.0-12.9	T/A	0	0	0	0	0	0	0	2.1	0	0	2.1	2.1	2.1	0	0	0	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	0	0	0	1.7	0	0	1.7	1.7	1.7	0	0	0	0	0	0	0	0	0	0	0
13.0-14.9	T/A	0	4.8	0	1.6	0	4.8	0	4.8	0	1.6	0	0	0	0	0	1.6	0	0	1.6	1.6	1.6	0	1.6	1.6
	BA/A	0	5.0	0	1.7	0	5.0	0	5.0	0	1.7	0	0	0	0	0	1.7	0	0	1.7	1.7	1.7	0	1.7	1.7
15.0-16.9	T/A	2.4	0	2.4	2.4	0	0	0	2.4	0	1.2	0	0	0	0	0	0	0	1.2	1.2	1.2	0	1.2	0	1.2
	BA/A	3.3	0	3.3	3.3	0	0	0	3.3	0	1.7	0	0	0	0	0	0	0	1.7	1.7	1.7	0	1.7	0	1.7
17.0-18.9	T/A	3.8	1.9	0	0.9	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0
	BA/A	6.7	3.3	0	1.7	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0
19.0-20.9	T/A	1.5	0.8	0	0.8	0.8	0	0	0.8	0	0	0	0	0	0.8	0	0	0	0	0	0.8	0	0	0	0
	BA/A	3.3	1.7	0	1.7	1.7	0	0	1.7	0	0	0	0	0	1.7	0	0	0	0	0	1.7	0	0	0	0
21.0-22.9	T/A	0.6	0	0	0	0	0	0.6	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	1.7	0	0	0	0	0	1.7	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.0-24.9	T/A	0.5	0	0	0	0.5	0	0	0.5	0.5	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
	BA/A	1.7	0	0	0	1.7	0	0	1.7	1.7	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0
25.0-26.9	T/A	0.9	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	3.3	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.0-28.9	T/A	0.8	0	0.4	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	2.3	0	1.7	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.0-30.09	T/A	0.7	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	3.3	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.0-32.9	T/A	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33.0-34.9	T/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0
51.0-52.9	T/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0
	BA/A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0
TOTAL	T/A	11.2	7.5	3.1	5.7	5.3	4.8	0.6	160.3	0.9	11.1	2.1	10.4	10.4	3.9	4.8	75.0	0.5	1.2	2.8	4.5	1.6	1.2	1.6	2.8
	BA/A	26.6	10.0	6.7	8.4	6.8	5.0	1.7	26.8	3.4	3.4	1.7	1.7	1.7	3.4	1.7	16.7	1.7	1.7	3.4	6.8	1.7	1.7	1.7	3.4
Percent	T/A	29.3	19.6	8.1	14.9	13.9	12.6	1.6	78.6	0.4	5.4	1.0	5.1	5.1	1.9	2.4	100.0	4.7	11.3	26.4	42.5	15.1	21.4	28.6	50.0
(Within Species)	BA/A	40.9	15.3	10.3	12.9	10.4	7.7	2.5	61.0	7.8	7.8	3.9	3.9	3.9	7.8	3.9	100.0	11.1	11.1	22.2	44.5	11.1	25.0	25.0	50.0

TABLE 6--Incidence of Diseases and Insect Damage in the Creek Stand #2, Cle Elum RD by Tree Species and DBH Class

DBH CLASS		DOUGLAS-FIR							WESTERN LARCH				GRAND FIR	LODGEPOLE PINE	[illegible]INE CEDAR
		Healthy	FM Live	DM-PW Live	PW Dead	DM-PW Dead	DM-FA Dead	Unk. Dead	DM Live	DM-PW Live	DM Dead	DM-FA Dead	Healthy	DM-Live	Healthy
1.0-4.9	T/A	0	95.8	0	4.2	0	0	4.2	0	0	0	0	75.0	0	0
5.0-6.9	T/A	0	38.3	0	4.3	0	0	4.3	4.3	0	0	0	12.8	0	0
	BA/A	0	7.5	0	0.8	0	0	0.8	0.8	0	0	0	5.0	0	0
7.0-8.9	T/A	2.4	43.0	0	0	0	0	2.4	7.2	0	7.2	0	7.2	0	0
	BA/A	0.8	15.0	0	0	0	0	0.8	2.5	0	2.5	0	2.5	0	0
9.0-10.9	T/A	0	35.1	4.6	0	0	0	0	1.5	1.5	0	1.5	7.6	0	1.5
	BA/A	0	19.2	2.5	0	0	0	0	0.8	0.8	0	0.8	4.2	0	0.8
11.0-12.9	T/A	2.1	20.2	0	1.1	1.1	1.1	0	0	1.1	0	1.1	1.1	1.1	0
	BA/A	1.7	15.8	0	0.8	0.8	0.8	0	0	0.8	0	0.8	0.8	0.8	0
13.0-14.9	T/A	2.3	14.8	0.8	0	0	0	0	0	0	0	0	0	0	0
	BA/A	2.5	15.8	0.8	0	0	0	0	0	0	0	0	0	0	0
15.0-16.9	T/A	1.8	4.2	0	0	0	0	0	0.6	0	0	0	0.6	0	0
	BA/A	2.5	5.8	0	0	0	0	0	0.8	0	0	0	0.8	0	0
17.0-18.9	T/A	0.9	3.7	0	0.5	0	0	0	0.5	0.5	0	0	0	0	0
	BA/A	1.7	6.7	0	0.8	0	0	0	0.8	0.8	0	0	0	0	0
19.0-20.9	T/A	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	0	4.2	0	0	0	0	0	0	0	0	0	0	0	0
21.0-22.9	T/A	0.3	0.9	0	0	0	0	0	0.3	0	0	0	0.3	0	0
	BA/A	0.8	2.5	0	0	0	0	0	0.8	0	0	0	0.8	0	0
23.0-24.9	T/A	0	0.8	0	0	0	0	0	0	0	0	0	0.3	0	0.3
	BA/A	0	2.5	0	0	0	0	0	0	0	0	0	0.8	0	0.8
25.0-26.9	T/A	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0
27.0-28.9	T/A	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0
29.0-30.9	T/A	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0
40.0-41.9	T/A	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0
47.0-48.9	T/A	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0
	BA/A	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0
Total	T/A	9.8	259.9	5.4	10.1	1.1	1.1	10.9	14.4	3.1	7.2	2.6	104.9	1.1	1.8
	BA/A	10.0	101.6	3.3	2.4	0.8	0.8	1.6	6.5	2.4	2.5	1.6	14.9	0.8	1.6
Percent (within species)	T/A	3.3	87.1	1.8	3.4	0.4	0.4	3.6	52.7	3.7	26.4	9.5	100.0	100.0	100.0
	BA/A	8.3	84.3	2.7	2.0	0.7	0.7	1.3	50.0	18.5	19.2	12.3	100.0	100.0	100.0

TABLE 7--Incidence of Diseases and Insect Damage in the Wenatchee River Stand, Lake Wenatchee RD by Tree Species and DBH Class

DBH CLASS		DOUGLAS-FIR				GRAND FIR			RED CEDAR		PONDEROSA-LODGEPOLE PINE	
		Healthy	BM Live	DM Live	AM Dead	Healthy	BM Live	AM Dead	Healthy	Unk. Dead	Healthy	DM Live
1.0-4.9	T/A	0	10.0	0	10.0	150.0	0	10.0	30.0	0	10.0	0
5.0-6.9	T/A	20.4	0	0	0	10.2	0	0	20.4	0	0	0
	BA/A	4.0	0	0	0	2.0	0	0	4.0	0	0	0
7.0-8.9	T/A	11.5	0	0	0	5.7	0	0	11.5	0	0	0
	BA/A	4.0	0	0	0	2.0	0	0	4.0	0	0	0
9.0-10.9	T/A	7.3	0	0	0	0	0	3.7	7.3	0	3.7	0
	BA/A	4.0	0	0	0	0	0	2.0	4.0	0	2.0	0
11.0-12.9	T/A	12.7	0	0	0	2.5	0	0	0	0	2.5	0
	BA/A	10.0	0	0	0	2.0	0	0	0	0	2.0	0
13.0-14.9	T/A	18.7	0	0	0	1.9	0	0	0	0	0	0
	BA/A	20.0	0	0	0	2.0	0	0	0	0	0	0
15.0-16.9	T/A	12.9	0	5.7	0	4.3	1.4	0	1.4	0	0	0
	BA/A	18.0	0	8.0	0	6.0	2.0	0	2.0	0	0	0
17.0-18.9	T/A	3.4	0	2.3	0	1.1	1.1	0	0	0	0	0
	BA/A	6.0	0	4.0	0	2.0	2.0	0	0	0	0	0
19.0-20.9	T/A	1.8	0	2.8	0	0.9	0	0	0	1.8	0	0
	BA/A	4.0	0	6.0	0	2.0	0	0	0	4.0	0	0
21.0-22.9	T/A	0.8	0	0.8	0	0	0	0	1.5	0	0	0
	BA/A	2.0	0	2.0	0	0	0	0	4.0	0	0	0
23.0-24.9	T/A	0	0	1.9	0	0	0	0	0.6	0	0	0
	BA/A	0	0	6.0	0	0	0	0	2.0	0	0	0
25.0-26.9	T/A	0	0	1.1	0	0.5	0	0	0	0	0	0
	BA/A	0	0	4.0	0	2.0	0	0	0	0	0	0
29.0-30.9	T/A	0	0	0.8	0	0.4	0	0	0	0.4	0	0
	BA/A	0	0	4.0	0	2.0	0	0	0	2.0	0	0
35.0-36.9	T/A	0	0	0	0	0	0	0	0	0	0	0.3
	BA/A	0	0	0	0	0	0	0	0	0	0	2.0
39.0-40.9	T/A	0	0	0.2	0	0	0	0	0	0.2	0	0
	BA/A	0	0	2.0	0	0	0	0	0	2.0	0	0
Total	T/A	89.5	10.0	15.6	10.0	177.5	2.5	3.7	72.7	2.4	6.2	0.3
	BA/A	72.0	<0.1	36.0	<0.1	22.0	4.0	2.0	20.0	8.0	4.0	2.0
Percent (within species)	T/A	71.5	8.0	12.5	8.0	96.6	1.4	2.0	96.8	3.2	95.4	4.6
	BA/A	66.7	<0.1	33.3	<0.1	78.6	14.3	7.1	71.4	28.6	66.7	33.3

TABLE 8--Incidence of Diseases and Insect Damage in the [redacted]ek Stand, Winthrop RD by Tree Species and DBH Class

DBH CLASS		DOUGLAS-FIR					ENGELMANN SPRUCE			SUBALPINE FIR		LODGEPOLE PONDEROSA PINE	
		Healthy	BW Live	DM Live	BB Dead	Unk. Dead	Healthy	BW Live	Unk. Dead	BW Live	Unk. Dead	Healthy	DM Live
1.0-4.9	T/A	0	10.0	0	0	0	0	10.0	10.0	50.0	20.0	10.0	20.0
5.0-6.9	T/A	0	30.6	0	0	0	0	30.6	0	0	0	0	0
	BA/A	0	6.0	0	0	0	0	6.0	0	0	0	0	0
7.0-8.9	T/A	0	11.5	0	0	0	0	5.7	0	0	0	0	22.9
	BA/A	0	4.0	0	0	0	0	2.0	0	0	0	0	8.0
9.0-10.9	T/A	0	3.7	3.7	0	0	0	14.7	0	3.7	0	0	0
	BA/A	0	2.0	2.0	0	0	0	8.0	0	2.0	0	0	0
11.0-12.9	T/A	2.5	5.1	0	0	0	2.5	2.5	0	7.6	0	2.5	0
	BA/A	2.0	4.0	0	0	0	2.0	2.0	0	6.0	0	2.0	0
13.0-14.9	T/A	0	1.9	0	0	1.9	0	3.7	0	0	0	1.9	0
	BA/A	0	2.0	0	0	2.0	0	4.0	0	0	0	2.0	0
15.0-16.9	T/A	1.4	0	0	0	0	0	1.4	0	0	0	1.4	0
	BA/A	2.0	0	0	0	0	0	2.0	0	0	0	2.0	0
17.0-18.9	T/A	0	1.1	0	0	0	0	0	0	0	0	0	0
	BA/A	0	2.0	0	0	0	0	0	0	0	0	0	0
19.0-20.9	T/A	0.9	0.9	0	0	0	0	1.8	0	0	0	0	0
	BA/A	2.0	2.0	0	0	0	0	4.0	0	0	0	0	0
21.0-22.9	T/A	0.8	1.5	0	0	0	0	0	0	0	0	0	0
	BA/A	2.0	4.0	0	0	0	0	0	0	0	0	0	0
23.0-24.9	T/A	0	0	0	0	0	0	0.6	0	0	0	0	0
	BA/A	0	0	0	0	0	0	2.0	0	0	0	0	0
27.0-28.9	T/A	0	0.9	0	0	0	0	0	0	0	0	0	0
	BA/A	0	4.0	0	0	0	0	0	0	0	0	0	0
33.0-34.9	T/A	0.3	0.3	0	0.3	0	0	0	0	0	0	0	0
	BA/A	2.0	2.0	0	2.0	0	0	0	0	0	0	0	0
37.0-38.9	T/A	0	0	0	0	0.3	0	0	0	0	0	0	0
	BA/A	0	0	0	0	2.0	0	0	0	0	0	0	0
39.0-40.9	T/A	0	0	0	0	0	0	0	0	0	0	0.2	0
	BA/A	0	0	0	0	0		0	0	0	0	2.0	0
Total	T/A	5.9	67.5	3.7	0.3	2.2	2.5	71.3	10.0	61.3	20.0	16.0	42.9
	BA/A	10.0	32.0	2.0	2.0	4.0	2.0	30.0	<0.1	8.0	<0.1	8.0	8.0
Percent (within species)	T/A	7.4	84.8	4.6	0.4	2.8	3.0	85.0	12.0	75.4	24.6	27.2	72.8
	BA/A	20.0	64.0	4.0	4.0	8.0	6.3	93.7	<0.1	100.0	<0.1	50.0	50.0

Fig. 1 Laminated decay caused by *Phellinus weirii*

Fig. 2 Mycelial fans of *Armillaria mellea* beneath the bark of a killed ponderosa pine

WENATCHEE NATIONAL FOREST

(north portion)

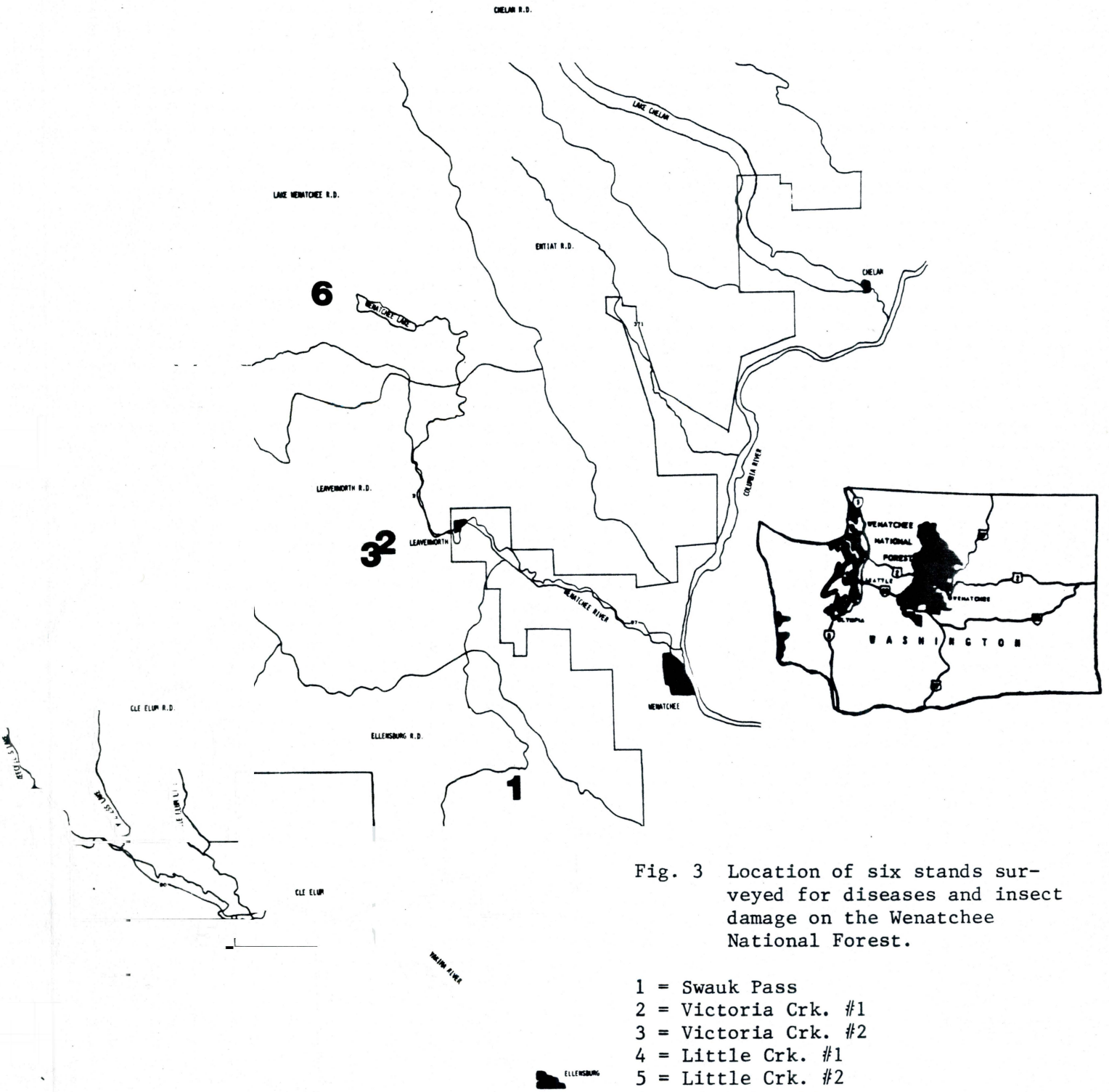

Fig. 3 Location of six stands surveyed for diseases and insect damage on the Wenatchee National Forest.

1 = Swauk Pass
2 = Victoria Crk. #1
3 = Victoria Crk. #2
4 = Little Crk. #1
5 = Little Crk. #2
6 = Wenatchee River

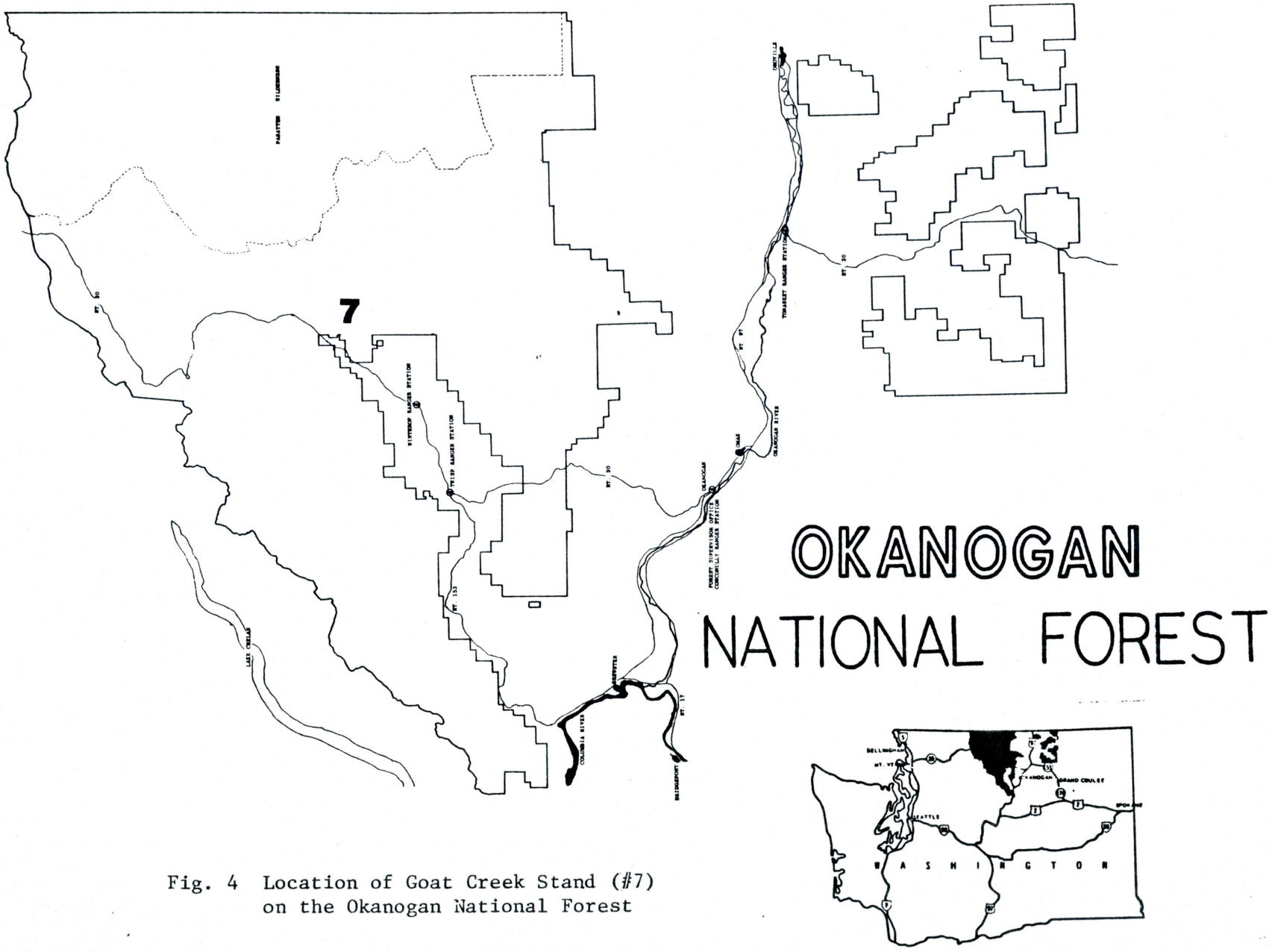

Fig. 4 Location of Goat Creek Stand (#7) on the Okanogan National Forest